LAC LA BICHE

Alberta

ENVIRONMENT
Water Quality Control Branch
Pollution Control Division

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Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Water Quality Control Branch of Alberta Environment.

As you read through the brochure, you may find you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics.** Refer to this for further interpretation.

Brochures are available for the following lakes:

Sandy Lake	Pine Lake	Lac La Biche
Lac La Nonne	Garner Lake	Nakamun Lake
Wizard Lake	Skeleton Lake	Wabamun Lake

DECEMBER, 1984

One of the focal points for recreation in Alberta's lakeland is Lac La Biche. This large, scenic lake is located 200 km northeast of Edmonton on Highway 55. The town of Lac La Biche on its southern shore and the village of Plamondon at its western end provide goods and services.

There are several public and private campgrounds on the lake; Sir Winston Churchill Provincial Park on Big Island is especially attractive.

Fishing

Sport fishing has always been popular in Lac La Biche, although many people believe the Walleye (pickerel) population has declined. The lake has been fished commercially since about 1920. Fish species include Whitefish, Tulibee, Northern Pike (Jackfish), Walleye and Perch. The commercial fishing season covers about six months of the year.

Physical Characteristics

As the Depth Contour map shows, there are two basins in Lac La Biche. The western basin, or "Big Lake", is the deepest (maximum 21 m or 70 feet). The eastern basin has a depth of 12 m (40 feet).

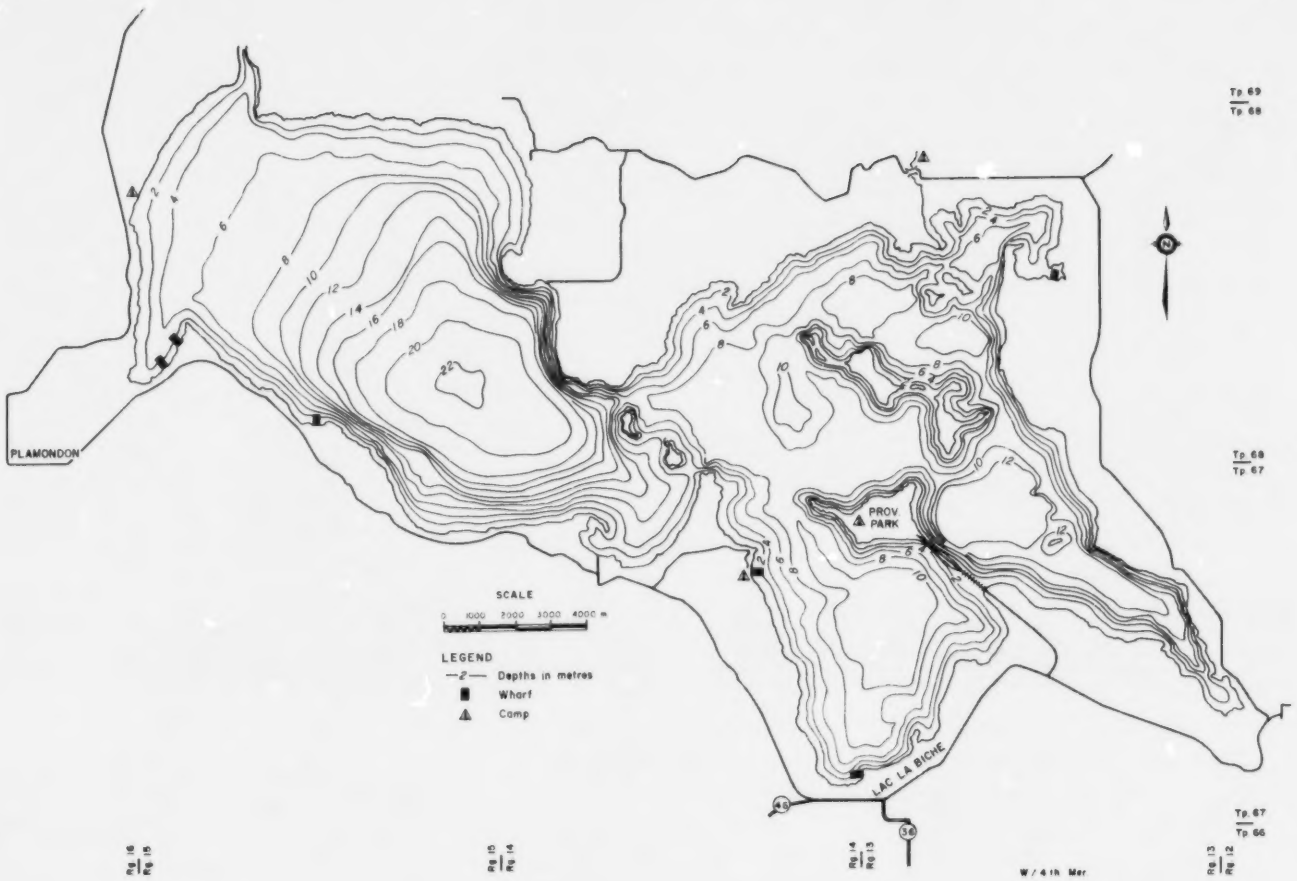
The largest inflow, the Owl River, enters the lake at a marshy delta on the northeastern shore. The outflow called the La Biche River leaves the lake at its northwestern corner and joins the Athabasca River.

Nutrient Sources

The watershed of Lac La Biche is large and contains many lakes and sloughs (see map). Usually when a lake's watershed is large compared to the size of the lake, the lake will be more eutrophic (have poorer water quality) than a lake with a proportionately smaller watershed. But this is offset somewhat for Lac Lac Biche because most of its watershed is undeveloped — it is largely in natural bush. Additionally, the lakes and sloughs take up some of the phosphorus that would otherwise enter Lac La Biche. Yet, as anyone who has seen the lake knows, Lac La Biche is very eutrophic — more so than can be explained by the nutrient supply from the watershed.

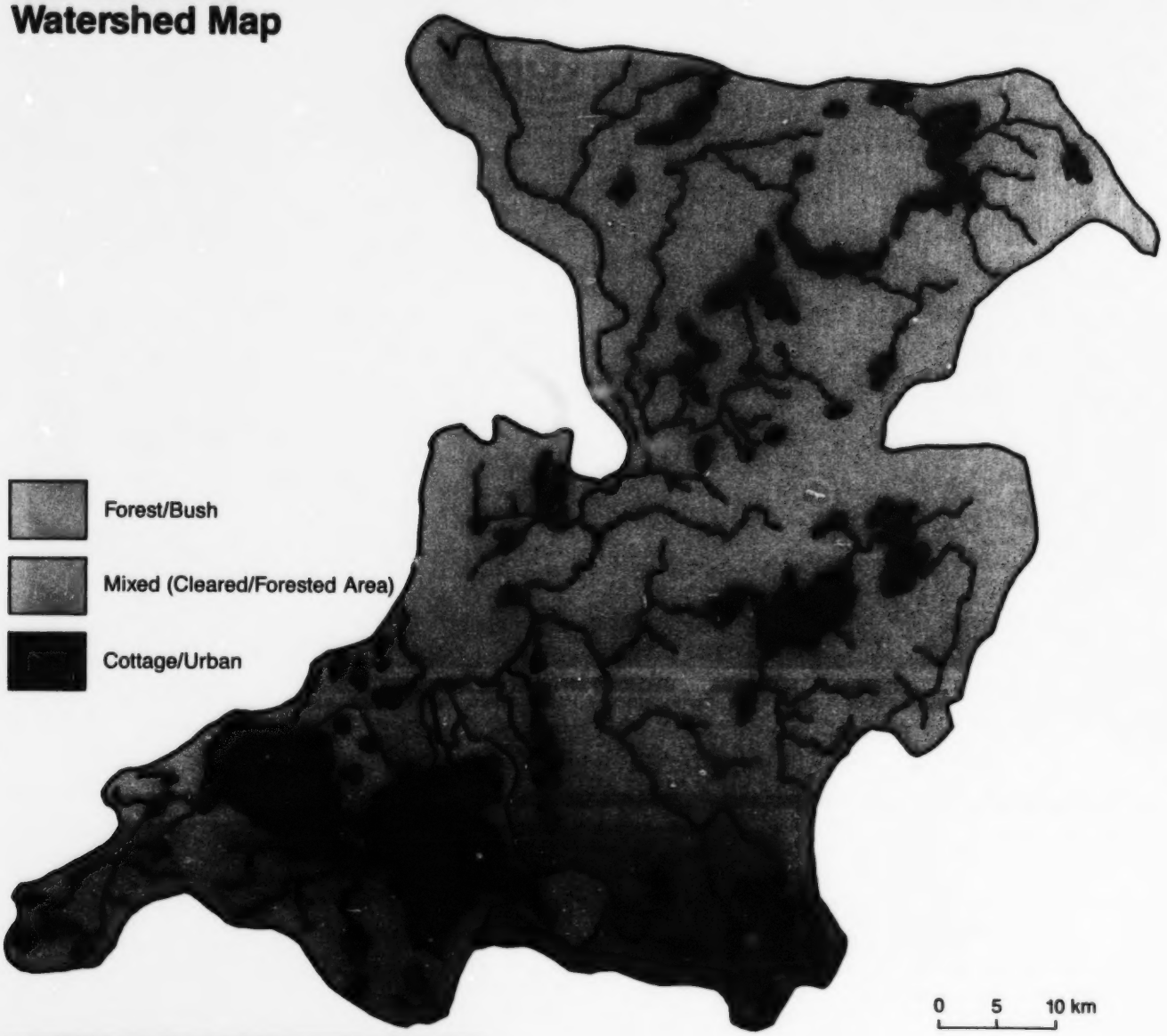
Lake users have often blamed sewage effluent from the town of Lac La Biche for the intense algal blooms that sometimes occur on the lake. Although the effect cannot be assessed because there is no information on the condition of the lake before the lagoon was built, it is likely that the effluent has had little effect on the lake as a whole. However, the effluent may have increased the quantity of algae in the bay near the town. The town's new lagoon, completed in 1981, does not discharge to the lake.

Depth Contour Map



PHYSICAL AND HYDROLOGICAL CHARACTERISTICS		
LAKE AREA	km^2	230.
DRAINAGE AREA (excluding lake)	km^2	4,070.
DRAINAGE AREA/ LAKE VOLUME		2.1
VOLUME	m^3	1,930. x 10^6
MAXIMUM DEPTH	m	21.
MEAN DEPTH	m	8.4
INFLOW	m^3	450. x 10^6
RESIDENCE TIME	years	4.3

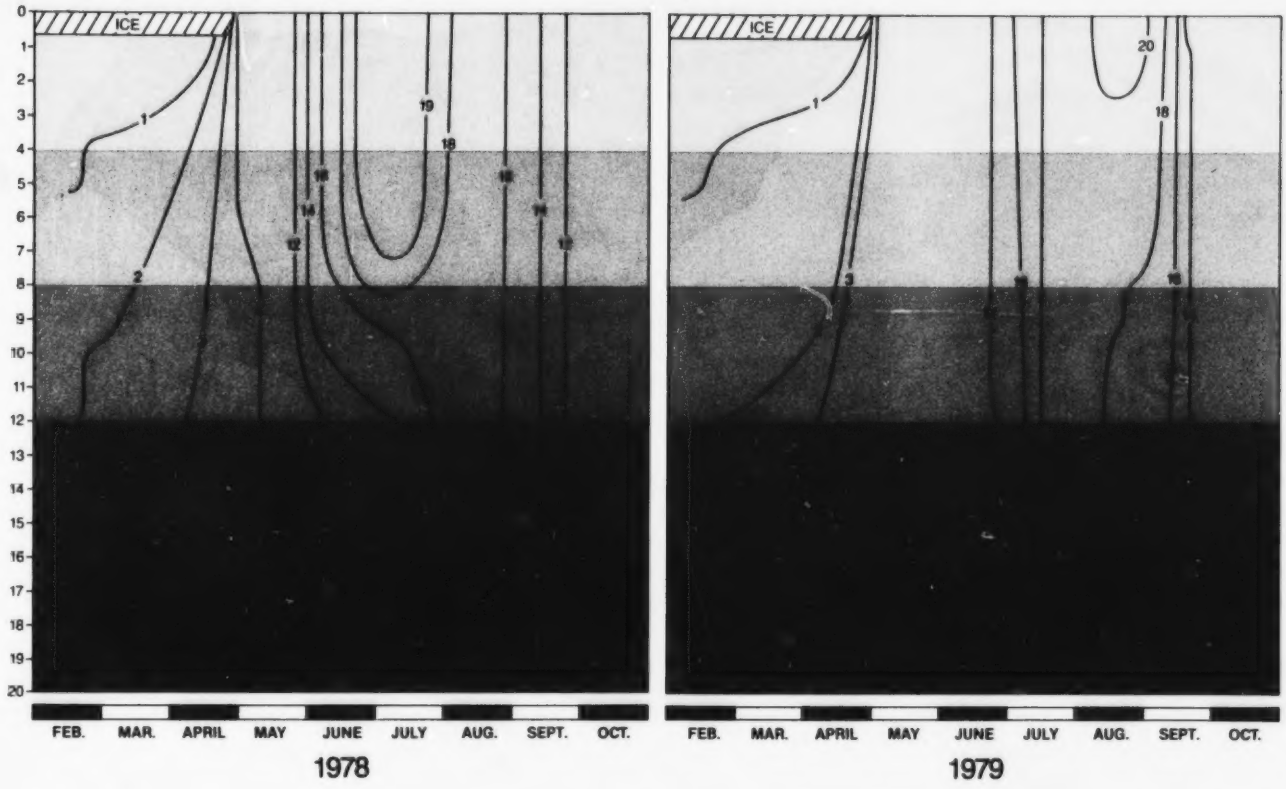
Lac La Biche Watershed Map



THEORETICAL PHOSPHORUS SUPPLY, kg/year

Surface Run-off:	
Forested Area	22,280.
Cleared Area	5,496.
Urban, Cottages	541.
Precipitation, Dustfall	7,194.
Upstream Lakes	4,637.
Sewage from all cottages and camps and Plamondon	414.
TOTAL	40,562.
Areal loading, g/m² of lake surface	0.18

Temperature (°C)

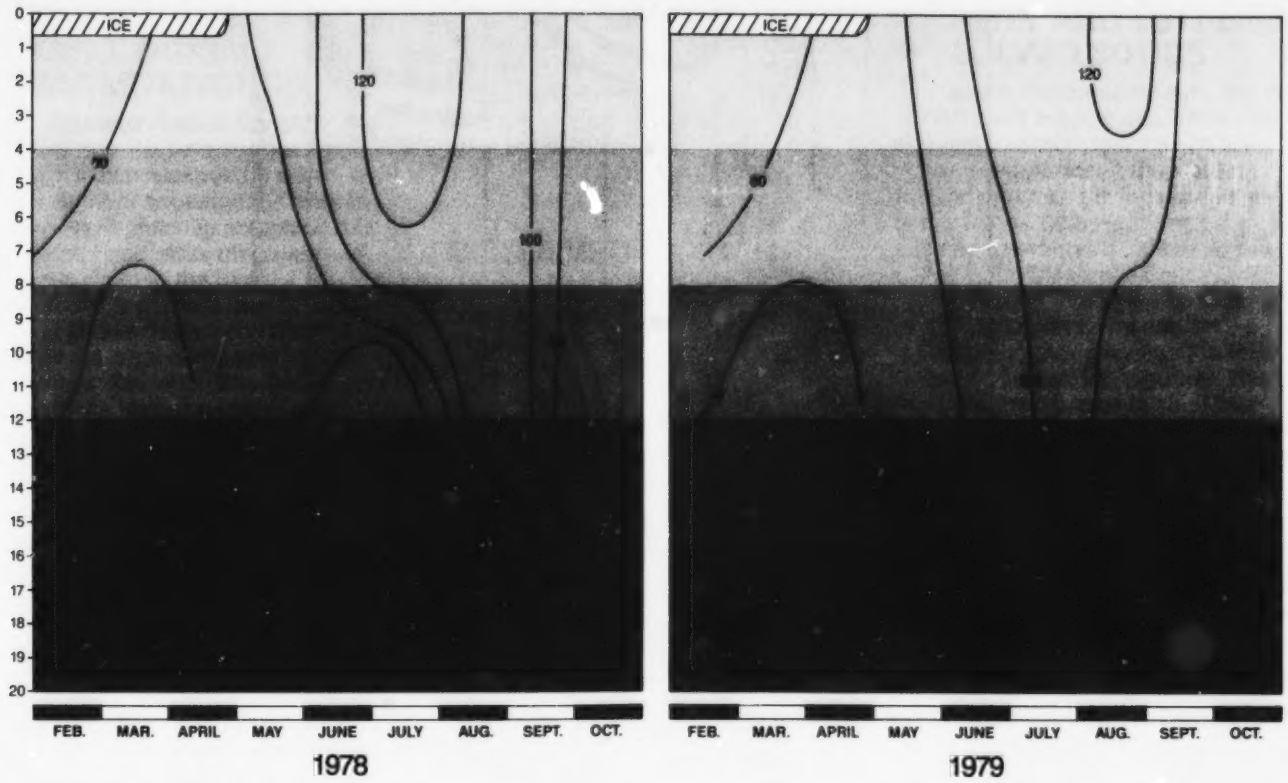


Temperature

The looped lines on the temperature graph indicate that Lac La Biche was temporarily layered in mid-summer both years in the deepest area of the west basin. Temperature measurements from shallower areas showed little evidence of this layering, but it is likely that layers form and are disrupted by wind all summer in Lac La Biche.

See "EXPLANATION OF LAKE CHARACTERISTICS" at end of brochure for clarification of these graphs.

Dissolved Oxygen (% Saturation)



Oxygen

During the period of layering, oxygen declined to zero near the bottom (see Dissolved Oxygen graph). This has important implications for water quality in the lake. As the quantity of oxygen declines, the chemistry of the mud and water changes. Phosphorus that would stay chemically bound in the mud when oxygen was present moves into the water.

On the next windy day, the phosphorus is mixed into the upper water, promoting the growth of algae. It is likely that much of the algal growth in summer results from the recycling of phosphorus from the bottom mud. This would explain why Lac La Biche is as eutrophic as it is.

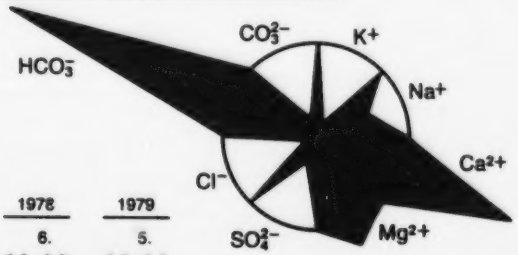
Lac La Biche has had winter fish kills in the past, although there was sufficient oxygen in late winter in 1978 and 1979.

Fish kills in a lake as deep as Lac La Biche probably only occur when a combination of adverse conditions arise: a late algal bloom and calm days before ice forms, and then a long winter with heavy snow cover. The snow cover prevents light penetration, so there is little algal photosynthesis to replenish the oxygen supply in late winter. Fish die as the oxygen runs out before ice break up.

Chemistry

Calcium and bicarbonate are the dominant ions in Lac La Biche. This is a typical pattern for many Alberta lakes. Salinity and total dissolved solids are quite low. The range of pH is wide — the lower values are from samples taken near the lake bottom. All of these averages are well within a favorable range for fish and other aquatic life.

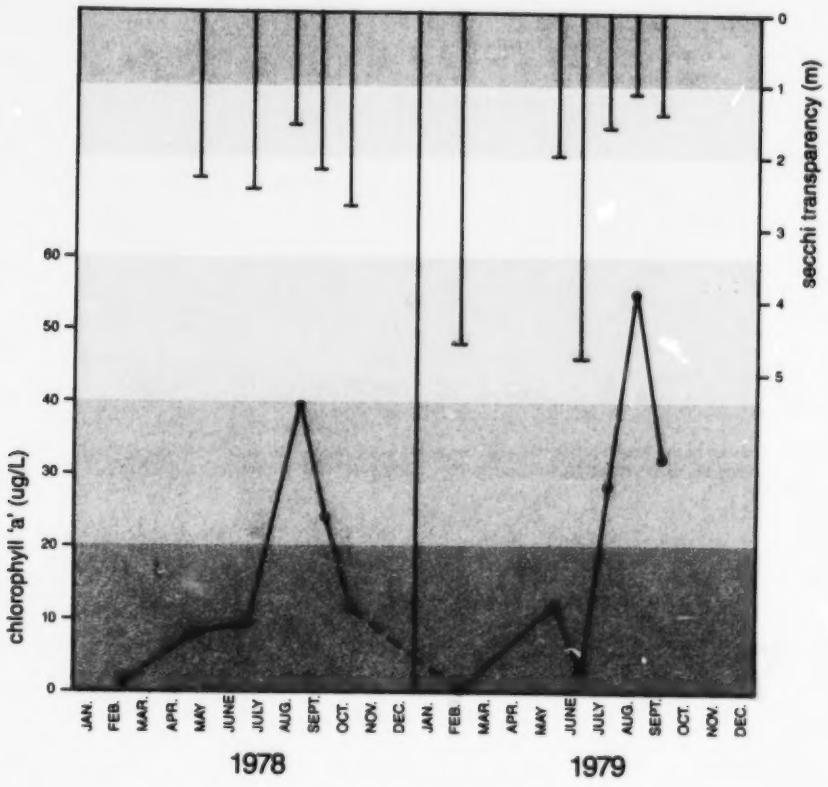
IONIC DIAGRAM — Relative proportions of Ions 1978, 1979



CHEMISTRY — Ice free season averages

		1978	1979
TOTAL SALINITY	meq/L	6.	5.
pH (RANGE)		7.5 - 9.0	6.7 - 9.0
ALKALINITY	mg/L	128.	119.
TOTAL DISSOLVED SOLIDS	mg/L	141.	128.

Trophic Status



Algae and Trophic Status

Blue-green algal blooms — those dense scums that wash onto beaches — are notorious in Lac La Biche. The intensity of these blooms varies from year to year, depending on climatic conditions. Even though the algal blooms were slightly worse in 1979 than in 1978, and very heavy in 1980, this fluctuation is typical of hignly eutrophic lakes and does not indicate rapid deterioration.

The graphs above show the variation in the amount of algae, as measured by the chlorophyll content of the water, over the two summers studied. The pattern was similar — algae were most abundant in August both years. The vertical lines above the chlorophyll graph show the transparency of the water. As might be expected, the water was least clear when algae were abundant.

The graphs show average quantities for the whole lake. But the east basin was usually more eutrophic than the west basin, perhaps because the east basin is shallower. Even within the east basin, the amount of algae will vary from one area to another on the same day. The bay on which the town of Lac La Biche is situated may pile up with algae whenever the prevailing northwest winds are strong. The causeway to the provincial park probably traps algae on one side or the other, depending on which way the wind blows. It is not known how the causeway has affected circulation patterns in the lake.

Conclusion

Lac La Biche may be termed highly eutrophic. But this condition, characterized by intense algal blooms in mid-summer, is largely a result of natural conditions. Especially important is its mixing pattern, with alternating periods of layering and mixing depending on wind. It is probable that this affects the lake's water quality as much as present human activities around the shoreline.

TROPHIC CHARACTERISTICS — ice-free season averages

		1978	1979
PHOSPHORUS	ug/L	73.	78.
NITROGEN	mg/L	1.03	1.05
CHLOROPHYLL	ug/L	20.	22.
SECCHI TRANSPARENCY	m	2.2	2.2
TOTAL NUMBER OF BENTHIC ORGANISMS			2135/m²
Oligochaeta			15% of total
Chironomidae			68% of total

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake volumes, (i.e. when this **Drainage Area/Lake Volume** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar size.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time,** which indicates the time it would take the inflow to completely fill an empty lake.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom. Because this colder water is denser, it resists mixing into the warmer, lighter upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom from wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4 °) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

The diagram(s) show temperature at each depth over the annual cycle. Similar temperatures over time are connected by lines called isotherms. Vertical lines indicate mixing, while horizontal lines indicate layering.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. It enters the lake water from the air through wind action, and plant photosynthesis.

Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts toward consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (Fish are stressed when oxygen falls below about 20% saturation — shown in red on the diagram). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens during an algal bloom on calm nights.

The diagram shows oxygen saturation at each depth over the annual cycle. Similar saturations over time are connected by lines called isopleths. Vertical lines indicate uniform saturation from top to bottom, while horizontal lines indicate stagnation near the bottom.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids.**

The ions* that make up most of this residue can be measured individually, giving a value for **Total Salinity** when added together. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

*Ions: Chemical form in water of constituents such as sodium and carbonate.

PH AND ALKALINITY

The pH of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral — neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic.** Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic.** In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits the recreational use of the lake. Lake users consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status.**

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/ Parkland areas of Alberta range between 10 and 120 ug/L, or oligotrophic to highly eutrophic, and nitrogen ranges between 0.5 and 3.5 mg/L.

Transparency declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disc,** which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the Secchi transparency.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll,** the green photosynthetic pigment.

The number of animals living in the bottom mud of the lake also may indicate its fertility. **Oligochaeta** are tiny worms; **Chironomidae** are immature stages of a fly called a midge.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply of all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North American, the quantity of phosphorus contributed by a hectare of forest is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in the Baptiste Lake watershed.

In all studies, the phosphorus supply from cleared or agricultural land was greater than that from forest, averaging 5 times more.

The "theoretical" phosphorus supply is estimated, without actually measuring it, by multiplying phosphorus supply factors for each type of land use by the area of that land use.

Similar factors are used for the supply from precipitation. The supply from sewage assumes that all sewage enters the lake, since it is nearly impossible to measure this source in lakes. Therefore, the number reported represents the maximum possible supply from that source.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.